

WATER SUPPLY
— OF —
THE CITY OF NEWARK, N.J.



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DEPARTMENT OF PUBLIC WORKSDIVISION OF WATERTHE WATER SUPPLY OF THE CITY OF NEWARK, NEW JERSEYHISTORY 200

The history of the water supply of The City of Newark, New Jersey extends from the period of "The Watering Place" in 1666 to complete ownership of the Pequannock Development and partnership in the Wanaque Development at the present time. This history includes the development by the Newark Aqueduct Company; the creation of the Newark Aqueduct Board and its Belleville Works on the Passaic River; the Pequannock Supply built for the City by the East Jersey Water Company; and the partnership in the Wanaque Supply of the North Jersey District Water Supply Commission.

THE WATERING PLACE: In the original layout of Newark, following its settlement in 1666, the founders set aside a small triangular plot on the south side of Market Street, west of Washington Street, which was known as "The Watering Place". (See 1 on Map of Water Supply System). Settlers watered their cattle there or carried water away in pails for home use. For more than a century after the founding of Newark, water supply was dependent upon this watering place near the "Four Corners" and upon wells dug as the need arose. Town pumps were established at different points. A number of fire cisterns were also constructed beneath the streets, consisting of brick chambers with arched top and an opening through which the water could be pumped out and used to extinguish fires.

THE NEWARK AQUEDUCT COMPANY: In 1800 farsighted citizens, seeing the need for a water supply system to serve the rapidly growing community, incorporated the Newark Aqueduct Company. It was created by an Act of the Legislature of the State of New Jersey passed November 17, 1800. The Company laid wooden conduits of logs about 12-inches in diameter, bored with a 4-inch hole. The logs were pointed at one end, reamed out at the other end and driven together to form a continuous pipe line. They were laid along Market Street to convey water from the springs west of High Street and south of 13th Avenue which supplied the old "Watering Place". Branch lines were laid along several side streets. It was the wonder of the age when the streets were opened for the laying of these first mains. Queries were made without number, and many an old timer viewed with alarm the new fangled notion of bringing water from distant springs to the back door. Well water was good enough, many people thought. The alarmist was abroad, as he is in every generation, predicting all sorts of evil consequences. The Town might be flooded some day when the pipes had rotted away, and other calamities were sure to follow.

The first reservoir in the system was probably 106-feet long and 38-feet wide, with a depth of about 12-feet, constructed at South Orange Avenue and Springfield Avenue, to collect the water from the springs in this locality. (See 2 on Map of Water Supply System). Cast-iron pipe was soon substituted for the wooden conduits. Just when this was done is not known, but perhaps it was about 1830 for the 10-inch outlet pipe from this reservoir, uncovered in a cellar excavation about 1915, was of cast-iron of a very early pattern.

The sequence of subsequent additions to the system are in doubt, but it seems reasonable to assume that at about this same time, (1830), water from springs south of Sussex Avenue and east of First Street was conducted by another iron pipe line to a small reservoir north of Orange Street, between Boyden and High Streets. This pipe ran for about 800 feet in the bed of the Morris Canal. It seems likely that it was laid at the time the canal was being built, between 1827 and 1836, to supply the northerly portion of the Town.

The next step of expansion of the Newark water supply is believed to have taken place between 1840 and 1845. A rather elaborate system of springs, driven wells and connecting pipe lines on both sides of the Morris Canal was constructed in the little valley north of Orange Street and west of Clifton Avenue, now covered in part by Branch Brook Park Lake. (See 3 on Map of Water Supply System). Seventy-three (73) wells and springs, with pipes and gates, were revealed when the lake was drained a few years previous to 1900. Considered of monster size, a 12-inch cast-iron pipe passing under the Morris Canal conveyed water from the springs and wells on the west side to a small covered reservoir in the Branch Brook basin near Seventh Avenue. Water from the springs and driven wells east of the canal also flowed to this reservoir, as did water from the springs previously referred to, south of Sussex Avenue and east of First Street. From this reservoir the water flowed through a 10-inch pipe to another reservoir at the old Needle Factory on Mill Brook, just west of what is now Clifton Avenue. About 40-feet long, 30-feet wide, and 14-feet deep, it was known as the "Reservoir in the Quarry". From this reservoir a 10-inch cast-iron pipe ran easterly to Quarry Street (now 8th Avenue) at Factory Street, and continued in Quarry Street to Broad Street, and in Broad Street to Orange Street. At the Needle Factory, and also at the Washington Factory located lower down on Mill Brook, at what is now Factory Street, opposite Drift Street, were additional springs from which the water was pumped by water power, and when that failed, by steam power. Most of these features are referred to in the Agreement between the Newark Aqueduct Company and the Newark Aqueduct Board dated December 9, 1845; and all are shown on a map of the Aqueduct Company's property as of 1855, which is in the files of the Division of Water of The City of Newark.

In this supplementing of the supply, and perhaps as the first step, wells were driven in the old spring lot south of Sussex Avenue and in the vicinity of the old Lock Street school on the east side of Lock Street north of Central Avenue and connected to the pipe line running to the Orange Street reservoir previously referred to as supplying the northerly portion of the Town.

BEGINNING OF MUNICIPAL SUPPLY: Agitation for municipal ownership of the water supply of The City of Newark began in 1837, the year following the adoption of the City Charter. A Bill was passed by the New Jersey State Legislature on February 28, 1838, empowering the City to raise money for a water plant. The private interests owning the Aqueduct Company were powerful enough, and shrewd enough, to have inserted in the Act a provision compelling the City to buy out the Company. Instead, the City entered into a contract with the Aqueduct Company on December 9, 1845 for a water supply for fire-fighting purposes, and assumed all future responsibilities in regard to the development of the system of pipes for distributing the water to fire hydrants and cisterns, while the Aqueduct Company continued to supply the domestic needs of the citizens of Newark.

Agitation for, and study of the possibilities of obtaining a municipal supply from other sources continued. On September 6, 1856 a committee appointed by the Common Council of The City of Newark reported that Second River could not be considered because of valuable mill sites, and that the Passaic River at Little Falls was also out of the question on account of preemption of water rights by private interests, the Society for the Establishing of Useful Manufactures. The rights of the Morris Canal Company were also considered, and Lake Hopatcong, Budd Lake and other sources were inspected, but all were too distant. The only sources remaining were those of the Aqueduct Company and the Passaic River below Paterson.

NEWARK AQUEDUCT BOARD: On March 20, 1860 the New Jersey State Legislature created the Newark Aqueduct Board, composed of the Mayor and six (6) citizens, and transferred to it the entire holdings of the Newark Aqueduct Company for the sum of \$150,000.00, giving the Board the right to operate and develop the system. The Board was authorized to issue bonds to this amount, bearing interest at seven (7) percent, and redeemable one-half (1/2) in 1866 and one-half (1/2) in 1871. The holdings included the spring lots, properties along Mill Brook, the Branch Brook tract and reservoirs, (See 3 on Map of Water Supply System), together with the part of the distributing system still owned by the Company, consisting of seventeen (17) miles of water pipe, 14,000 feet being 10-inch, 3,500 feet being 8-inch, 7,000 feet being 6-inch, and the balance being 3-inch and under. Parts of this property were sold by the City for about \$70,000.00, and other parts, valued at \$75,000.00, were ultimately transferred to the Essex County Park Commission during the early years of the construction of Branch Brook Park.

Recommendations were immediately made by the Aqueduct Board's Engineer that a new source of supply be acquired either from the Passaic River or from the Morris Canal. Authority was granted by the New Jersey State Legislature of 1861 for the building of Works at Belleville to take water from the Passaic River. (See 4 on Map of Water Supply System). Construction was delayed by the Civil War, and the Board proceeded with such extensions and improvements of the old Works as were imperatively needed. The old springs were enlarged and deepened, but no considerable increase in flow resulted. In 1862 a new reservoir was built by cleaning out the old basin on Branch Brook, just east of the canal, and raising and strengthening the banks. In 1865 a second reservoir was built, adjoining the first on the north. The capacity of the two was about 12 million gallons. The level was about 87-feet above sea level, 10 or 12-feet higher than the old reservoirs. This construction rendered the old reservoirs at Orange Street and at South Orange Avenue near High Street, as well as the "Reservoir in the Quarry", obsolete and they were abandoned. A 24-inch cast-iron main was laid in place of the original 10-inch from the new reservoirs to the corner of Quarry Street (now 8th Avenue) and Broad Street. Water in considerable quantity was also drawn directly from the Morris Canal, by agreement with the Morris Canal Company, for a stipulated price.

BELLEVILLE WORKS: In 1866 property was bought in Belleville for the authorized new Belleville Works. Construction began in 1867 and the new Works were put in operation in 1870. They consisted of (1) Belleville Reservoir, (See Page 12), on the top of the hill in Belleville, north of Belleville Avenue and west of Washington Avenue at elevation

165-feet above tidewater, having a capacity of fourteen (14) million gallons; (2) two basins each covering about an acre on the west bank of the Passaic River in the northeasterly corner of Belleville, (See 4 on Map of Water Supply System), into which ground water from the hills to the west and from the river could filter, and which were filled at each flood tide with water from the river; (3) a 5-foot intake conduit about 300-feet long, extending from the basins to the river bank; (4) a pumping station to lift the water from the collecting basins to the reservoir; and (5) two 30-inch cast-iron force mains extending from the pumping station to the reservoir. In September, 1871 South Orange Avenue Reservoir was completed as a high-service reservoir, to which water was pumped by a pumping engine located at the corner of Factory Street and 8th Avenue. This same year it was decided to build a new low-service distributing reservoir to take the place of the Branch Brook Reservoirs. A site in the old quarry hole west of what is now Clifton Avenue, opposite 7th Avenue, at an elevation of 114-feet above sea level, 27-feet higher than the old reservoirs, was selected, and during the next few years the Clifton Avenue Reservoir was built, together with a new high-service pumping station. Water from Belleville Reservoir was delivered to the suction well at the Clifton Avenue pumping station, from which it overflowed into Clifton Avenue Reservoir. The area east of the Pennsylvania Railroad was supplied from the Clifton Avenue Reservoir; the area between the railroad and High Street was supplied from Belleville Reservoir; the area west of High Street, except for the highest parts, was supplied from South Orange Avenue Reservoir; and the highest parts were supplied directly by pumping from the high-service pumping station.

Extensions to the distribution system were made, so that by 1876 it was reported to consist of one hundred twenty six (126) miles of mains as compared with nineteen (19) miles in 1860, and the average daily consumption had increased to 6,200,000 gallons daily from 800,000 daily in 1860.

DISSATISFACTION WITH PASSAIC RIVER WATER: No sooner were the Belleville Works completed and in use than complaints began to be made as to the quality of the water from the Passaic River which was affected by pollution from the cities of Passaic and Paterson farther up the river. In 1873 and 1874 agitation became quite active for a supply of water for Newark and Jersey City from the lakes and streams in the northerly part of the state. A period of improved quality of river water in the following two (2) years stopped the agitation for a time. Meanwhile, an attempt was made to "secure the water of the river from pollution" and it became increasingly evident that other source of water supply for The City of Newark must be procured. A report dated May 30, 1877 was prepared on the Morris Canal as a source of supply, but the special committee responsible for this report recommended that "owing to the heavy cost and the present depressed condition of our manufacturing and commercial interests" no action be taken.

PEQUANNOCK RECOMMENDED: In 1879, the eminent engineering firm of Croes & Howell, who had been engaged to report on a new water system, recommended obtaining a supply from the Pequannock River. About this same period, Mayor Haynes of Newark suggested the possibility of a cooperative effort on the part of a group of municipalities. This is probably one of the earliest considerations in water supply matters of the cooperative idea, which was consummated forty five (45) years later in the Wanaque Project. As against the plan of a public supply,

propositions were advanced for the purchase of water by the City from water works owned by private capital, such as the Society for the Establishing of Useful Manufactures, the Morris Canal, and other private interests. Bills were introduced in the Legislature to secure franchises for doing this, and the power of the City to acquire water outside its own limits was challenged. Public interest culminated in 1887 in a mass meeting, at which a committee was appointed composed of seven (7) leading citizens of the City and members of the Aqueduct Board. This committee presented a printed report approving a plan for a municipal water supply to be developed from the upper tributaries of the Passaic, and rejecting the idea of purchasing filtered Passaic River water from private water companies or driving more wells.

PEQUANNOCK SUPPLY

PEQUANNOCK SUPPLY BUILT BY EAST JERSEY WATER COMPANY: After negotiations, a contract was entered into on September 24, 1889 with the East Jersey Water Company - a consolidation of private interests owning property and water rights on the Passaic River and its tributaries, organized especially for the purpose - for the construction of storage reservoirs in the Pequannock Watershed and an aqueduct capable of delivering to Newark 50 million gallons of water daily, by May, 1892, for a total cost of \$6,000,000.00. By the date agreed upon, the Oak Ridge, Clinton and Macopin Reservoirs, and twenty-one (21) miles of 48-inch steel pipe were completed and the first Pequannock water was delivered to Belleville Reservoir. For the deferment of the payment of \$2,000,000.00 of the total, the East Jersey Water Company agreed to operate the supply works but to retain the right to 22.5 million gallons daily for a period of eight (8) years, or until September 24, 1900, during which period the City's allowance would be limited to 27.5 million gallons per day. Many controversies arose regarding the capacity of the pipe line and the adequacy of the storage. To assure the 50 million gallons daily supply to the City, the Company added the Canistear Reservoir to the storage and built a second steel pipe line in 1896.

EMERGENCY SUPPLY FROM BELLEVILLE WELLS: In 1898 the allotment of 27.5 million gallons daily which Newark had the right to draw from the Pequannock was insufficient for the City's needs, and during a severe cold spell early in the year it was necessary to pump water directly from the Passaic River at Belleville. To prevent a recurrence of this dangerous emergency measure, and to make certain an adequate supply for the remaining two years until the entire Pequannock Plant should be turned over to Newark, a rather extensive system of driven wells was installed at the old Belleville pumping station. During 1898 and 1899 the City began the installation of water meters. The resulting curtailment of waste reduced the consumption of water to such a point that the limitation until 1900 of 27.5 million gallons daily from the Pequannock caused no further shortage, and the driven wells at Belleville were never called upon for any continued supply.

PEQUANNOCK SUPPLY ACQUIRED BY NEWARK: Legal proceedings were instituted on the part of the City in 1900 to force the East Jersey Water Company to fulfill its Pequannock Supply Contract in regard to several points in controversy. Reports and testimony by the foremost Hydraulic Engineers of that period, John R. Freeman, Frederick P. Stearns,

J.J.R. Croes, and Desmond Fitzgerald, showed the need of additional works built by the East Jersey Water Company in 1896 to assure a yield and delivery of 50 million gallons daily from the Pequannock Watershed. The points in controversy were finally settled and a decree in Chancery was mutually agreed upon, which gave the City practically all it had claimed. All the reservoirs and pipe lines built by the Company on the Pequannock Watershed were turned over to the City on September 24, 1900, and with the final payment to the Company of \$2,000,000.00 the entire Pequannock Watershed Supply System became the property of The City of Newark.

SOURCE OF SUPPLY is the Pequannock River, a tributary of the Passaic River, located in the highlands of Northern New Jersey in Sussex, Morris and Passaic Counties. Supply works, for the most part, were built for The City of Newark by the East Jersey Water Company, a Company organized by several private interests who owned property and water rights on the river. Construction work was started in 1889 and completed in 1900.

THE PEQUANNOCK WATERSHED of the Newark Water Supply System embraces 63.7 square miles, from which, as developed, it is estimated that at least 57 million gallons of water daily can be obtained during the driest of years. The City controls 86 percent of this area, or about 35,000 acres, leaving 14 percent, or 5,800 acres, privately owned. Upon this watershed have been constructed the following four (4) storage reservoirs and one (1) intake reservoir:

OAK RIDGE RESERVOIR with an area of 482 acres, an elevation of flow line 846-feet above sea level, a capacity of 3895 million gallons at this elevation, and a tributary area of 21.7 square miles below Canistear Reservoir. Oak Ridge Reservoir was constructed between 1889 and 1892 with a flow line 10-feet lower than the present level, and with 1300 million gallons less capacity. The dam was raised 10-feet during the years from 1917 to 1919. The overflow and discharge from Canistear Reservoir passes into or through Oak Ridge Reservoir.

CLINTON RESERVOIR with an area of 423 acres, an elevation of flow line 992-feet above sea level, a capacity of 3518 million gallons at this elevation, and a tributary area of 10.5 square miles. It was constructed between 1889 and 1892.

CANISTEAR RESERVOIR with an area of 350 acres, an elevation of flow line 1086-feet above sea level, a capacity of 2407 million gallons at this elevation, and a tributary area of 5.6 square miles. It was constructed between 1892 and 1900 as a supplement to the original storage, required in order that the Pequannock development would be capable of supplying not less than 50 million gallons of water daily.

ECHO LAKE RESERVOIR with an area of 300 acres, an elevation of flow line (with 1-foot flashboards) 894-feet above sea level, a capacity of 1678 million gallons at this elevation, and a tributary area of 4.6 square miles. This was originally a natural body of water whose surface was raised between 1889 and 1892 in the original construction work, and from which the City had the right to draw water, but which was not owned by the City. Subsequently, from 1921 to 1925, the entire rights to the reservoir were purchased and improvements were made which increased the available storage to the present figure.

MACOPIN INTAKE RESERVOIR with an area of 12.1 acres, an elevation of flow line 583.55-feet above sea level, a capacity of 32 million gallons at this elevation, and a tributary area below the other reservoirs of 21.3 square miles. It was constructed between 1889 and 1892. The overflow and discharge from all other reservoirs pass into or through this reservoir.

The drainage of the westerly section of the Pequannock Watershed is gathered into Oak Ridge Reservoir, the northeasterly into Clinton Reservoir, the northwesterly into Canistear Reservoir, and the easterly into Echo Lake Reservoir. Other than Macopin Intake Reservoir there is no storage reservoir for the 21.3 square miles comprising the southerly portion of the watershed. From the storage reservoirs water is drawn as required and flows in the natural stream beds to Macopin Reservoir, which is the intake reservoir.

TOTAL STORAGE in the Pequannock Reservoirs is 11,530,000,000 gallons with flashboards at Echo Lake Dam at elevation 894. Available storage equals 10,500,000,000 gallons, about half a year's supply at the present rate of consumption.

PEQUANNOCK AQUEDUCT: At Macopin Intake Reservoir, as the name implies, the water is let into the aqueduct which conveys Pequannock water to Newark. This Pequannock Aqueduct consists of two (2) riveted-steel pipes which run parallel for about twenty-one (21) miles past Great Notch to Belleville Reservoir. The two (2) pipe lines are cross-connected at several points but can be operated separately and independently. The so called No. 1 Line is 48-inch and was constructed 1889 to 1892. In 1896 the No. 2 Line was constructed. This Line is 48-inch for a distance of about five (5) miles, and 42-inch for the remainder of its length. A program for reconditioning the interior of the pipe lines started in 1933, was continued by successive steps and completed in 1948, with the major portion of the lining being cement. The exception is the 42-inch No. 2 Line, which was lined with bituminous enamel from Broad Street, Bloomfield to Belleville Reservoir.

CEDAR GROVE RESERVOIR, located on the mountain above Montclair, has an area of 100 acres, an elevation of flow line 405-feet above sea level, and a capacity of 679 million gallons at this elevation. Built to provide a reserve of about a fifteen (15) day supply close to the City, it was put in service in 1904. Because it furnishes opportunity for clarification and sedimentation by storage, and insures clear and pure water to the City, it is the main distributing reservoir of the Pequannock Supply.

A 60-inch steel pipe, about a mile long, conveys water to this reservoir from the Pequannock pipe lines at Great Notch. Connection at Great Notch is so arranged that water from either or both Pequannock pipes can be turned into the reservoir or shut off as may be desired.

TRANSMISSION LINES FROM CEDAR GROVE RESERVOIR: The outlet tunnel, of horseshoe section 7-feet high by 7-feet wide, about 3,000 feet long through the mountain east of the reservoir, conveys water out of Cedar Grove Reservoir. From the east portal of this tunnel, seven (7) miles of 60-inch steel pipe passes through Montclair, Glen Ridge and Bloomfield, and extends to Newark to the Bloomfield Avenue Tower at Sixth Street. This line was completed in 1904 as part of the original Cedar Grove Reservoir construction work. The so called Alexander

Avenue Connecting Aqueduct, also a 60-inch steel line, completed in December, 1943, connects the original 60-inch line, at a point about a mile east of the east portal of Cedar Grove Tunnel, with the No. 1 and No. 2 Pequannock pipe lines to Belleville Reservoir and with them provides an alternate path for water to Newark and the Bloomfield Avenue Tower.

From the Bloomfield Avenue Tower, so called, (a gate house at Sixth Street housing meters which record the flow through five (5) of six (6) main feeders), Pequannock water is distributed throughout Newark. The highest portions of the City, such as the Vailsburg, Roseville, Clinton Hill and Silver Lake sections, are supplied directly from Cedar Grove Reservoir, in some cases through pressure reducing valves. The High-Pressure Fire System in downtown Newark is likewise supplied directly. Two (2) 36-inch lines and a 48-inch line convey water from the Bloomfield Avenue Tower to South Orange Avenue Reservoir for distribution therefrom as hereinafter described; two (2) 36-inch lines supplemented for more than half of the distance by a 48-inch line extend between Belleville Reservoir and Bloomfield Avenue Tower; and one (1) 36-inch line, supplying the Roseville area under reduced Cedar Grove Reservoir pressure, extends through this area to a closed valve in Branch Brook Park near Clifton Avenue and 8th Avenue, at which point the line connects with the Low-Pressure System of downtown Newark so that high-pressure water may be supplied in an emergency to maintain the required low-pressure.

SANITARY CONTROL AND WATER TREATMENT: Every precaution is taken to safeguard the Pequannock Supply. City owned property, comprising 86 percent of the entire watershed area, is posted and policed to exclude undesirable persons. A regular program of reforestation and of silviculture, under the direction of a professional Forester, has as its object the eventual forestation of all of this property. Since 1930 more than 5,000,000 trees have been planted on the watershed. The important portions of the 110 miles of streams are cleaned and patrolled to minimize pollution. Garbage and waste is removed from all occupied properties, whether owned by the City or not, and disposed of at a disposal plant. Outside toilets are cleaned and all materials disposed of outside the watershed. A local physician is constantly on watch for cases of sickness on the watershed. The Water Department maintains its own laboratory where daily tests are made of physical characteristics such as color, taste, odor and turbidity, of micro-organisms, and of bacteria, in the water delivered to Cedar Grove Reservoir and to the City. Weekly physical, microscopical and bacteriological tests are made of the waters of all main streams on the watershed. Monthly chemical analyses of Cedar Grove Reservoir water are also made in the laboratory. Daily determinations of pH and chlorine residual are made at treatment points. Independent bacteriological and sanitary supervision is exercised by the Newark Department of Health and by the State Department of Health.

As water enters the aqueducts at the intake at Macopin it is sterilized with chlorine. Ammonia, in varying amounts, depending upon the season, is added previous to chlorination, thereby reducing the amount of chlorine required and producing more satisfactory results. After this so called chloramine treatment, the water goes to Cedar Grove Reservoir, where as a result of aeration, storage and exposure to sunlight, it is improved in clarity, color and taste.

All Pequannock water to the City out of Cedar Grove Reservoir is given a secondary treatment of chlorine at the Valley Road Treatment Plant located at the head of the 60-inch pipe line near the east portal of Cedar Grove Reservoir Outlet Tunnel. This addition to the system was put in service in October, 1942. Provision is made for the application of ammonia as well as chlorine. The Valley Road Treatment Plant makes it possible to carry a residual of chlorine into the distribution system to provide this additional factor of safety to the Pequannock water served to Newark consumers.

During the summer and fall months, as conditions require, Belleville and South Orange Avenue Reservoirs are treated continuously with chlorine as a precaution against chance pollution. Ammonia also is sometimes added.

From time to time, as microscopical examinations of streams and reservoir waters show the presence of micro-organisms that affect taste and odor, such waters are treated with copper-sulphate or chlorine. This treatment destroys organisms before they increase to such an extent as to be offensive.

WANAQUE SUPPLY

EARLY HISTORY OF WANAQUE SUPPLY: As early as 1879 the Wanaque River was recognized as a possible source of water supply in a report to The City of Newark, which, while recommending the Pequannock as the best source of additional water supply, suggested and studied the Wanaque as an alternative plan. The old State Water Supply Commission of 1882 also recommended this source but gave preference to the Pequannock because of its lower cost. As a result, the Pequannock supply was constructed for Newark during the years 1889 to 1900 and nothing was done at that time on the development of the Wanaque Reservoir.

NORTH JERSEY DISTRICT WATER SUPPLY COMMISSION CREATED: In 1916 the North Jersey District Water Supply Commission was created with provision that funds for water supply projects in the water supply district should be furnished by municipalities interested in obtaining additional water from a joint cooperative project which the North Jersey District Water Supply Commission should build.

WANAQUE CONSTRUCTED: Under such legislation the Wanaque water supply project was constructed by the North Jersey District Water Supply Commission between the years 1920 and 1930 at the expense of Newark and seven (7) other municipalities, Newark for the first few years bearing all of the cost of construction, but finally being reimbursed by the other municipalities for their shares of the project. Originally estimated to cost about \$9,000,000.00 for a 50 m.g.d. supply for Newark alone, the project was enlarged by several steps during construction, as other municipalities contracted to enter. The final project for 100 m.g.d. cost approximately \$25,000,000.00 exclusive of interest during construction. Newark's 40.5 m.g.d. cost about \$15,000,000.00 including about \$3,500,000.00 for interest during construction.

SOURCE OF SUPPLY is the Wanaque River, a tributary of the Passaic River located principally in Passaic County but extending into New York State, northeast of and adjoining the Pequannock Watershed.

Supply Works were built and operated by the North Jersey District Water Supply Commission for The City of Newark and seven (7) other municipalities. Construction work was started in 1920 and completed in 1930. Use of Wanaque water in the Newark system began at 9:30 P.M. July 5, 1930. Wanaque water cannot be delivered to the higher portions of the City.

THE WANAQUE WATERSHED embraces 94.4 square miles from which, during all but the driest of years, it is expected that an average of about 100 million gallons daily of water can be obtained. This is allocated to the participants as follows:

Newark	40.5 m.g.d. *	Clifton	6.75 m.g.d.
Paterson	20 m.g.d.	Montclair	5 m.g.d.
Kearny	12 m.g.d.	Bloomfield	4 m.g.d.
Passaic	11 m.g.d.	Glen Ridge	0.75 m.g.d.

* Newark also controls Bloomfield's 4 m.g.d. share through an exchange of Pequannock water and other monetary consideration.

WANAQUE RESERVOIR: The storage reservoir of this development has an area of 2300 acres and a capacity of 27,600 million gallons at flow line elevation of 300-feet above sea level. With 1-foot of flash-boards on the spillway the storage with water level at elevation 301 equals 28,780 million gallons.

RAYMOND DAM: The main dam of Wanaque Reservoir is located in the Borough of Wanaque, near the Village of Wanaque, in the County of Passaic, New Jersey, and is called Raymond Dam in honor of Mayor Raymond of Newark, during whose administration, and under whose leadership this fine water supply development was constructed. It is an earth dam, 1500-feet long and 100-feet high above the original ground surface, with concrete core wall to bed rock 90-feet below the original surface. Slightly more than a million cubic yards of earth are contained in this structure.

Seven (7) other smaller dams close low points in the hills surrounding the reservoir. A concrete overflow weir 550-feet long is just south of Raymond Dam.

WANAQUE AQUEDUCT conveys water from Wanaque Reservoir at Raymond Dam to Belleville Reservoir, from which point a 60-inch steel pipe line extends to Newark, where it connects at various points with the Newark distribution system, and through Newark to the Elizabeth City Line, where Newark delivers Wanaque water to that City. Connections with the Pequannock system exist at Belleville Reservoir, and at the Pompton River in Wayne where the Wanaque and Pequannock aqueducts cross one another.

The Wanaque aqueduct consists of (a) 485 feet of 84-inch reinforced concrete pipe laid in a tunnel through the rock wall just south of the Raymond Dam, at one end connected by about 300 feet of 84-inch steel pipe with the headworks at the dam, and at the lower end extended with 100 feet of 84-inch steel pipe to a connection chamber; (b) from this point 72,950 feet of twin 74-inch lock-bar steel pipe line, cross connected at six (6) points, followed by 161 feet of single 74-inch lock-bar steel pipe extending to a tunnel through the mountain at

Great Notch; (c) Great Notch Tunnel, of horseshoe section, concrete lined, 7-feet high by 7-feet wide, with a length of 9400 feet and with 66-inch reinforced concrete pipe placed inside of the tunnel for a distance of 462 feet at the westerly end and 944 feet at the easterly end to resist internal water pressure for which the tunnel was not originally designed; and (d) 24,340 feet of single 74-inch lock-bar steel pipe from Great Notch Tunnel to the Newark take-off at Belleville Reservoir.

WANAQUE PUMPING STATION, located at Raymond Dam, makes the full head of the Wanaque Reservoir available for transmitting water through Wanaque Aqueduct. Whenever necessary, as the water surface in the reservoir drops, the pumps may be operated to raise the head on the aqueduct to that corresponding to a water surface at elevation 300.

A BALANCING RESERVOIR for equalizing the flow in the Wanaque Aqueduct is located in Clifton near the easterly end of Great Notch Tunnel. It is a covered concrete reservoir having a capacity of 15 million gallons, with overflow at elevation 258.

WATER TREATMENT: Water as it leaves Wanaque Reservoir is chlorinated after ammonia gas is added to produce the chloramine treatment found so successful on the Pequannock supply. Wanaque water is also lime treated to overcome its natural acidity. The lime is added after the chlorine. Now and then, during the year as required, copper sulphate is applied to the water in portions of the reservoir to control growths of micro-organisms. Aerators are provided at Raymond Dam for use as required to eliminate taste and odors but they are not generally used. The very large storage in Wanaque Reservoir produces a water low in color, free from turbidity and of good bacterial quality.

DISTRIBUTION SYSTEM

Pequannock water, which is delivered from Cedar Grove Reservoir at elevation 405, can be supplied to all portions of Newark. However, it is used principally in the higher portions of the City. Wanaque water, from Wanaque Reservoir at elevation 300, can be delivered only to the lower lying portions of Newark.

Pequannock water delivered to the Bloomfield Avenue Tower is measured by five (5) meters as it is distributed throughout the City by means of six (6) feeder mains. Due to the elevations of Cedar Grove, South Orange Avenue and Belleville Reservoirs, the desired pressures are obtained throughout the City by the creation of three (3) pressure zones fed by gravity from each of these reservoirs. The highest portions of the City, such as the Vailsburg, Roseville, Clinton Hill and Silver Lake sections, are supplied directly from the Cedar Grove Reservoir, in some cases through pressure reducing valves. The High-Pressure Fire System in downtown Newark is also supplied by this method. Two 36-inch lines and a 48-inch line convey water from the Tower to South Orange Avenue Reservoir for distribution in the South Orange Avenue Reservoir Level, a narrow strip west of High Street and extending to Belmont Avenue. The Belleville Reservoir Level includes the downtown section of the City, which is supplied with Wanaque water delivered to the Belleville Reservoir.

SOUTH ORANGE AVENUE RESERVOIR, located at South Orange Avenue and South 8th Street, Newark, is an equalizing reservoir for the portion of Newark lying west of Elizabeth Avenue, High Street and Summer Avenue, and east of Peshine Avenue and Branch Brook Park. It has an area of 1.7 acres, an elevation of flow line 225-feet above sea level, and a capacity of nine (9) million gallons at this elevation. It was completed in 1871 as the high-service distributing reservoir for the Belleville Works. Water was pumped to this reservoir from Clifton Avenue Reservoir. With the completion of the first part of the Pequannock Supply in 1892, which included a 36-inch steel pipe extension of the 48-inch No. 1 Pequannock pipe line from Belleville Reservoir to the South Orange Avenue Reservoir, the Clifton Avenue pumping station was abandoned and Pequannock water was supplied directly by gravity to the highest portions of Newark and to South Orange Avenue Reservoir for distribution therefrom, as first stated in this paragraph. Since the completion of Cedar Grove Reservoir in 1904 as the main distributing reservoir for the Pequannock Supply, South Orange Avenue Reservoir has received its supply of water, in general, directly from Cedar Grove Reservoir.

BELLEVILLE RESERVOIR, located in the Town of Belleville, just north of the Newark-Belleville Line, serves as an equalizing reservoir for the low portion of Newark east of Elizabeth Avenue, High Street and Summer Avenue, in which area Wanaque water has been used in large part since July 5, 1930 when the Wanaque Supply was completed and put in service to Newark. Both Pequannock and Wanaque water can be supplied to the reservoir, but Pequannock is usually used. It has an area of 2.5 acres, an elevation of flow line 165-feet above sea level, and a capacity of fourteen (14) million gallons at this elevation. It was completed in 1869 and put in service in 1870 as part of the Belleville Works, authorized by the Legislature of 1861 but not constructed until after the Civil War. Originally, water was pumped to it from collecting basins on the westerly bank of the Passaic River in Belleville. From Belleville Reservoir water was distributed to the low portion of Newark west of the Pennsylvania Railroad and to a small reservoir and pumping station located just west of Clifton Avenue opposite 7th Avenue - the Clifton Avenue Reservoir, until its abandonment in 1912, serving as the distributing reservoir for the portion of Newark east of the Pennsylvania Railroad, and the Clifton Avenue pumping station, until its abandonment in 1892, supplying directly the highest portions of the City and South Orange Avenue Reservoir. With the completion of the first stage of the Pequannock Supply in May, 1892, Belleville Reservoir was supplied with water by gravity through the Pequannock Aqueduct directly from Macopin Intake instead of by pumping from the basins at the Passaic River. Upon the completion of Cedar Grove Reservoir in 1904, water therefrom was supplied to Belleville Reservoir, supplemented by Pequannock water directly from Macopin at times of heavy draft. Since the completion of the 60-inch Alexander Avenue Connecting Aqueduct in December, 1943, Pequannock water into Belleville Reservoir comes entirely from Cedar Grove Reservoir.



WANAQUE RESERVOIR
FLOW LINE EL. 300.3
AREA 2310 ACRES
CAPACITY 28,010 MILLION GALS.

CHLORINE & AMMONIA
TREATMENT PLANT

WANAQUE AQUEDUCT
TWIN 74" STEEL PIPES

WANAQUE AQUE
GREAT NOTCH TUN

ECHO LAKE RESERVOIR
FLOW LINE EL. 894.0
AREA 300 ACRES
CAPACITY 1678 MILLION GALS.
TRIBUTARY AREA 4.6 SQ. MI.

CLINTON RESERVOIR
FLOW LINE EL. 992.0
AREA 423 ACRES
CAPACITY 3518 MILLION GALS.
TRIBUTARY AREA 10.5 SQ. MI.

PEQUANNOCK AQUEDUCT
48" & 42" STEEL PIPES

CHLORINE & AMMONIA
TREATMENT PLANT

CANISTEAR RESERVOIR
FLOW LINE EL. 1086.0
AREA 350 ACRES
CAPACITY 2407 MILLION GALS.
TRIBUTARY AREA 5.6 SQ. MI.

MACOPIN INTAKE RESERVOIR
FLOW LINE EL. 583.74
AREA 12.1 ACRES
CAPACITY 32 MILLION GALS.
TRIBUTARY AREA 21.3 SQ. MI.
BELOW OTHER RESERVOIRS

OAK RIDGE RESERVOIR
FLOW LINE EL. 846.0
AREA 482 ACRES
CAPACITY 3895 MILLION GALS.
TRIBUTARY AREA 21.7 SQ. MI.
BELOW CANISTEAR

NOTE REGARDING PEQUANNOCK SUPPLY
WATER IS DRAWN FROM ECHO LAKE, CLINTON,
CANISTEAR AND OAK RIDGE STORAGE RESERVOIRS
THROUGH OUTLET GATES AND FLOWS IN NATURAL
STREAMS TO THE MACOPIN INTAKE RESERVOIR.

SUBMITTED BY JAMES E. GARRATT
DESIGNING ENGINEER
DIVISION OF WATER

DRAWN BY R.B. THOMPSON

